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[54] **INTEGRATED LIQUID CRYSTAL DISPLAY AND DIGITIZER HAVING A BLACK MATRIX LAYER ADAPTED FOR SENSING SCREEN TOUCH LOCATION**

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[51] **Int. Cl.**[6] **G09G 3/36**; G09G 5/00

[52] **U.S. Cl.** **345/104**; 345/174

[58] **Field of Search** 345/104, 173, 345/174, 179; 359/54, 68; 349/110

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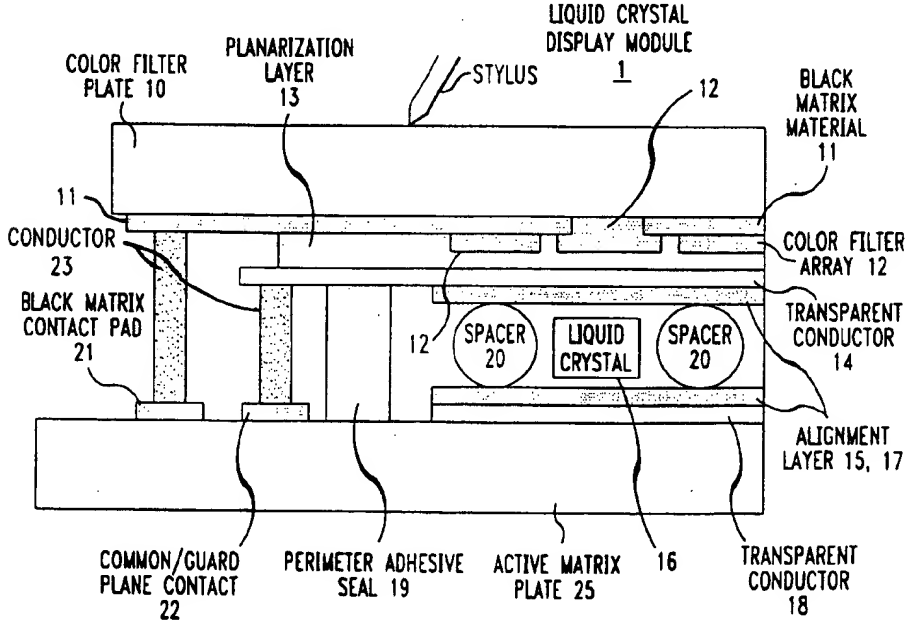
[57] **ABSTRACT**

A unitary display and sensing device integrates liquid crystal display module elements of a liquid crystal display module for detecting input on a flat panel display screen with the capability for digitizing the detected inputs. In accordance with an illustrative embodiment of the present invention, display elements of a liquid crystal display module are modified to sense input on the display screen. An electrical signal is applied to modified display elements of the liquid crystal display module so that contact with a surface portion of the display screen produces an output signal indicative of its location. The integrated display and sensing device is active matrix addressed for finger input, but may also incorporate display systems for active pen input.

13 Claims, 7 Drawing Sheets



of the color filter plate provides higher signal-to-noise performance for the digitizer by placing the sensing electrodes further away from the guard electrode. The distance between the sensing electrodes and guard electrodes is about 1–2 microns, when the black matrix material is patterned for sensing pen or finger input, whereas, the placement of a patterned ITO layer on the outside surface of the liquid crystal display module increases this separation to 1 millimeter. Also, the guard electrode could be split into rows and the black matrix layer into columns so that an active pen would detect input on the display screen.

The invention claimed is:

1. A liquid crystal display comprising:

a display screen;

an active matrix plate spaced apart from the display screen wherein the active matrix plate has a plurality of switching elements connected to an array of thin film transistors formed thereon;

a color filter plate positioned between the display screen and the active matrix plate wherein the color filter plate has a layer of black matrix material formed on a surface thereof; and

a transparent conductive layer positioned between the active matrix plate and the color filter plate wherein the layer of black matrix material and the transparent conductive layer are adapted to sense the location of an object touching the display screen based upon the relative size of the displacement current generated at the point of contact between the object and the display screen.

2. The liquid crystal display of claim 1 wherein the object is a finger.

3. The liquid crystal display of claim 1 wherein the object is a stylus.

4. The liquid crystal display of claim 1 wherein the layer of black matrix material is patterned into a plurality of strips of conducting material which are separated from each other by a plurality of isolation areas.

5. The liquid crystal display of claim 1 wherein the plurality of switching elements are adapted to have a plurality of gate lines and a plurality of row lines and wherein at least one of the plurality of isolation areas are aligned to one of the plurality of gate lines and the plurality of row lines of the plurality of switching elements on the active matrix plate.

6. The liquid crystal display of claim 4 wherein the layer of black matrix material is further patterned to have a plurality of resistive strings and a plurality of contact pads.

7. The liquid crystal display of claim 4 wherein at least one of the isolation areas is non-continuous.

8. The liquid crystal display of claim 7 further comprising a color filter array having a red filter, a blue filter and a green filter, wherein the at least one isolation area that is non-continuous is aligned to the blue filter of the color filter array.

9. A method of sensing the location of an object touching a surface portion of a display screen of a liquid crystal display comprising the steps of:

applying a signal to a black matrix layer of a liquid crystal display wherein the black matrix layer is patterned into a plurality of stripes of conducting material which are separated from each other by a plurality of isolation areas, and wherein the signal generates a current in the black matrix layer; and

generating a displacement current in response to an object touching a portion of a display screen of the liquid crystal display wherein the black matrix layer and a transparent conductive layer of the liquid crystal display sense the location of the object touching the display screen based upon the relative size of the displacement current generated at the point of contact between the object and the display screen.

10. The method of claim 9 wherein the object is a stylus.

11. The method of claim 9 wherein the object is a finger.

12. The method of claim 9 further comprising applying the signal to a transparent conductor of the liquid crystal display.

13. A method of sensing the location of an object touching a surface portion of a display screen of a liquid crystal display comprising the steps of:

applying a signal to a black matrix layer and a transparent conductor of a liquid crystal display wherein the black matrix layer is patterned into a plurality of strips of conducting material which are separated from each other by a plurality of isolation areas, and wherein the signal generates a current in the black matrix layer; and

generating a displacement current in response to an object touching a portion of a display screen of the liquid crystal display wherein the black matrix layer and the transparent conductive layer of the liquid crystal display sense the location of the object touching the display screen based upon the relative size of the displacement current generated at the point of contact between the object and the display screen.

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process passes to block **154**. Block **154** illustrates a determination of whether or not the application has terminated and, if not, the process returns in an iterative fashion to block **150** and continues to illuminate the tip of computer input stylus **92**. If, however, the application has been terminated, the process passes to block **156** and returns.

Referring again to block **152**, in the event a new color has been selected by the user, utilizing keystrokes or mouse selection clicks within the drawing program, the process passes to block **158**. Block **158** illustrates the calculation of the new color driver signals, and those signals are then passed to computer input stylus **92**, and the process returns in an iterative fashion to block **150**, where the stylus tip once again is illuminated with a color identical to the selected color.

Upon reference to the foregoing, those skilled in the art will appreciate that the Applicants have provided a computer input stylus in which the tip of the stylus is automatically illuminated with a color identical to the color selected by a user from a color palette within a drawing application. In this manner, the stylus assumes a real-world analogy to a paintbrush in that the tip of the paintbrush depicts the color selected by the user for application.

What is claimed is:

1. A computer-input stylus for use with a computer-implemented software drawing application, said computer-input stylus comprising:

a cylindrical body sized to be grasped by a human hand;

a tip attached to said cylindrical body;

a color display within said tip for illuminating said tip with a selected color indicative of a color currently selected within said software drawing application; and

control means coupled to said color display for altering said selected color in response to selection of an alternate color within said software drawing application.

2. The computer-input stylus according to claim **1** wherein said tip is constructed of a conical, optically transparent plastic.

3. The computer-input stylus according to claim **1** wherein said color display comprises a plurality of light-emitting diodes.

4. The computer-input stylus according to claim **1** wherein said color display comprises a thin film transistor (TFT) liquid crystal display.

5. The computer-input stylus according to claim **1** further including communication means for coupling said control means to a computer.

6. A computer drawing system comprising:

a processor;

a display coupled to said processor for displaying images;

a software drawing application operational within said processor for creating color images within said display in response to user inputs designating selected colors and locations; and

an input stylus coupled to said processor for designating locations within said display, said input stylus comprising:

a cylindrical body sized to be grasped by a human hand;

a tip attached to said cylindrical body;

a color display within said tip for illuminating said tip with a selected color indicative of a color currently selected within said software drawing application; and

control means coupled to said color display for altering said selected color in response to selection of an alternate color within said software drawing application.

7. The computer drawing system according to claim **6** wherein said tip is constructed of a conical, optically transparent plastic.

8. The computer drawing system according to claim **6** wherein said color display comprises a plurality of light-emitting diodes.

9. The computer drawing system according to claim **6** wherein said color display comprises a thin film transistor (TFT) liquid crystal display.

10. The computer drawing system according to claim **6** further including a communications means for coupling said control means to said processor.

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